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INTRODUCTION

During the period from June 1967 through September 1969 a series of critical experiments was performed at the Rocky Flats Critical Mass Laboratory with spherical and hemispherical plutonium assemblies as nested hemishells as part of a Nuclear Safety Facility Experimental Program to evaluate operational safety margins for the Rocky Flats Plant. These assemblies were both bare and fully or partially oil-reflected. Many of these experiments were subcritical with an extrapolation to critical configurations or critical at a particular oil height. Existing records reveal that 167 experiments were performed over the course of 28 months. Unfortunately, much of the data was not recorded. A reevaluation of the experiments had been summarized in a report for future experimental and computational analyses.[1]

This report examines only fifteen partially oil-reflected hemispherical assemblies. Fourteen of these assemblies also had close-fitting stainless-steel hemishell reflectors, used to determine the effective critical reflector height of oil with varying steel-reflector thickness. The experiments and their uncertainty in k_{eff} values were evaluated to determine their potential as valid criticality benchmark experiments of plutonium.

DESCRIPTION OF THE ACTUAL WORK

Hemispherical assemblies of plutonium hemishells with interstitial lithium-silicon grease and hydrocarbon oil weighing approximately 8.962 kg (±1%) with a nominal radius of 6.33 cm was attached to an aluminum mount and suspended within two concentric tanks that could be filled with hydrocarbon oil. The tanks were filled until criticality was achieved, and the effective height was recorded. Various thicknesses of stainless-steel hemishells ranging from 0.333 to 4.667 cm were attached to the mounted assembly to determine the effective change in oil height required to achieve criticality. The oil reflector was effectively infinite in all directions horizontally radial to and vertically below the mounted assembly.[2]

Experimental data was evaluated to account for variations in physical measurements, material compositions, and environmental influences. Systematic errors and biases were not assessed as insufficient data was available for accurate reconstruction. Homogenous and heterogeneous computational models were developed for analysis with MCNP5 using the ENDF/B-VI.8 cross section library. Some homogenous models were also created using KENO-VI using 238-group ENDF/B-VI.7 cross sections to provide comparative data.

RESULTS

The total uncertainty in the evaluated k_{eff} values for these experiments was large. The uncertainty ranged from 2.16 – 2.24% for the heterogeneous models and 2.19 – 2.34% for the homogenous models. The primary components of the overall uncertainty involved the potential effects of plutonium hydrolysis and the uncertainty in the exact contents of the gaps between the hemishells. The additional uncertainty in the plutonium mass and inclusion of an aluminum mount represented smaller yet significant contribution to the total evaluated uncertainty. Homogenization of the experiment, as performed in the evaluations of the original experimenters, added an additional 0.6% Δk to the total uncertainty.

Because the overall uncertainty in k_{eff} is significantly greater than 1%, these experiments were not considered acceptable as benchmark experiments to include in validations of calculational methods for plutonium. However, they represent a unique combination of materials (plutonium reflected by steel and oil) that might be used in specific evaluations where the high uncertainty can be tolerated. Further physical experimentation efforts to produce benchmark-quality evaluations should seek to reduce the effective uncertainties in hydrolysis effects, actual content of gaps between hemishells, mass of fissile material, and bias effects from the assembly mount.

REFERENCES

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